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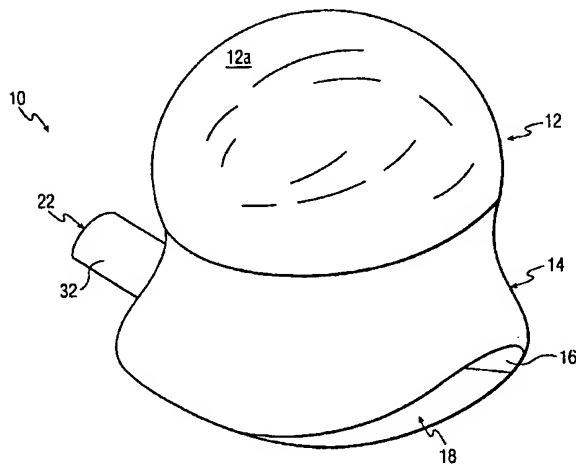
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[Continued on next page]

(54) Title: **ERGONOMIC HOUSING FOR ULTRASOUND TRANSDUCER PROBE**



(57) Abstract: Ultrasonic transducer probe housing including an upper portion defining a substantially spherical outer surface grippable by a probe operator and a lower portion defining a bottom of the housing and a cable exit opening through which a cable passes. The cable exit opening is positioned between the bottom and the upper portion of the housing. A cable conduit extends from the cable exit opening to lead the cable out of the housing at an angle of about 0° to about 30° relative to a horizontal plane of the housing perpendicular to a central, vertical axis thereof. Positioning the cable exit opening below the portion of the housing gripped by the operator, in combination with the orientation of the cable conduit at an angle to the horizontal plane of the housing, minimizes the effective weight/torque which arises during operative movement of the housing.

**Declarations under Rule 4.17:**

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU,

IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations

**Published:**

- without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

## ERGONOMIC HOUSING FOR ULTRASOUND TRANSDUCER PROBE

The present invention relates generally to ultrasound transducer probes used in ultrasound imaging systems and more particularly, to a housing for an ultrasound transducer probe that provides improved ergonomics to the operator of the probe during use.

5        Ultrasound transducer probes are often used for interoperative imaging of a patient's internal body parts. The probes, also referred to as a ultrasonic or ultrasound scanhead, include a housing and a transducer arranged in the housing in a position such that ultrasound waves are emitted from an active surface of the transducer toward the body part as the housing is passed over the body part. The transducer then receives ultrasound waves reflected from the body part. A cable is connected to the transducer and passing through an opening in the housing to connect the transducer to a control unit and allow for signal transmission between the transducer and the control unit. Signals representative of the received ultrasound waves are provided by the transducer to the control unit via the cable and processed by the control unit to obtain images of the body part.

10        A drawback in the use of ultrasound probes of this type is that the opening in the housing through which the cable passes is often arranged in a position which does not provide ergonomic use of the probe. For example, in some designs, the cable passes through an opening at the top of the housing of the probe, opposite to the body-contacting surface of the probe, and in a direction perpendicular to the active surface of the probe ("on axis"). Since the probe is held during operation at a position between the body-contacting surface and the top of the housing, and since constant pressure contact is required for suitable imaging, the cable exits the housing from a location above the hand of the operator and the operator is often required to exert a gripping force to securely hold the probe against possibly tension exerted by the cable and the probe/patient contact pressure. Moreover, the operator's wrist may be repeatedly deflected under pressure resulting from the cable's tension and torque.

25        As such, it would be desirable to provide a housing for an ultrasonic transducer which provides improved ergonomics.

30        It is an object of the present invention to provide a new transducer probe for use in internal ultrasound imaging systems, such as general abdominal and obstetric imaging applications.

It is another object of the present invention to provide a new ultrasonic transducer probe which is designed in consideration of ergonomic factors, e.g., to minimize the hand pressure, gripping force and wrist torque required to be exerted by an operator to operate the probe.

5           In order to achieve these objects and others, a housing for a transducer probe in accordance with the invention includes an upper portion defining a substantially spherical outer surface adapted to be gripped by an operator of the probe and a lower portion defining a bottom of the housing and a cable exit opening adapted to enable a cable to pass from an interior of the housing to an exterior of the housing. The cable exit opening is thus  
10           positioned between the bottom of the housing and the upper portion of the housing. Moreover, a cable conduit extends from the cable exit opening to lead the cable out of the interior of the housing at an angle of about 0° to about 30° relative to a horizontal plane of the housing perpendicular to a central, vertical axis thereof.

          The positioning of the cable exit opening below the portion of the housing gripped  
15           by the operator, preferably in combination with the orientation of the cable conduit at an angle to the horizontal plane of the housing, is effective to minimize the effective weight/torque which arises during movement of the housing and cable relative to a control unit which is coupled to the cable. During use, the operator's wrist is positioned above the cable exit opening and this has been found to provide a reduction in the impact of tension  
20           from the cable and torque being exerted by the cable on the operator's wrist. Furthermore, the substantially spherical outer surface is intended to provide a form suitable for maintaining a "wrist neutral", "natural power grip" hand and wrist position throughout scanning manipulation and to facilitate one-hand rotation of the probe for image plane changes during scanning.

25           In one embodiment, the housing is made of two, substantially mirror-image components, each having a hemispherical portion which provides half of the upper portion of the housing and a lower arcuate portion which provides half of the lower portion and includes a channel which provides half of the cable conduit. One or both of the housing components may be provided with a mounting structure to enable the transducer to be  
30           securely mounted to the housing. The components are provided with a cooperating or complementary attachment structure, e.g., a projection and a recess, to enable them to be secured together.

A transducer probe in accordance with the invention includes the housing in any of the forms described above, a transducer arranged in the interior of the housing and having an active surface oriented toward a bottom of the housing and a cable for connecting the transducer to a control unit of the probe. A lens may be attached to the housing or to the transducer in a position opposite the active surface of the transducer. A loadable, flexible epoxy material is optionally arranged in an interior of the housing and variably loaded to counter balance the cable.

Use of a probe including the housing described above provides improved ergonomic properties which enhance the operator's ease of use of the probe.

The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the  
5 accompanying drawings, wherein like reference numerals identify like elements and wherein:

FIG. 1 is a perspective view of a housing of an ultrasound transducer probe in accordance with the present invention.

FIG. 2 is an internal view of an ultrasound transducer probe including the housing  
10 shown in FIG. 1.

FIG. 3 is a front view of a first component of the housing shown in FIG. 1.

FIG. 4 is a bottom view of the housing component shown in FIG. 3.

FIG. 5 is a cross-sectional view of the housing component shown in FIG. 3 taken  
along the line 5-5 of FIG. 3.

15 FIG. 6 is an enlarged view of the section designated A in FIG. 5.

FIG. 7 is a front view of a second component of the housing shown in FIG. 1.

FIG. 8 is a bottom view of the housing component shown in FIG. 7.

FIG. 9 is a cross-sectional view of the housing component shown in FIG. 7 taken  
along the line 9-9 of FIG. 7.

20 FIG. 10 is an enlarged view of the section designated B in FIG. 9.

Referring to the accompanying drawings wherein like reference numerals refer to the same or similar elements, FIG. 1 shows a housing for an ultrasonic transducer probe in accordance with the invention which is designated generally as 10. The housing 10 includes an upper portion 12 having a substantially spherical outer surface 12a and a lower  
25 portion 14 having the approximate, general shape of a truncated cone. The upper portion 12

is designed such that the operator of the probe can easily place their hand over it. The lower portion 14 defines a bottom of the housing 10 and includes inwardly directed lips 16 defining an opening 18 through which ultrasonic waves are transmitted and received during use of the probe.

5           One of the objectives of a housing for a transducer probe in accordance with the invention is to facilitate operation of the probe by an operator. To this end, the spherical outer surface 12a of the upper portion 12 is designed to fit the "power grip" or natural position of the human hand and easily facilitate one-handed rotation and angulation of the probe.

10           Another objective of a housing in accordance with the invention is to provide an exit for a cable, which typically connects a transducer in the housing to a control unit which controls the probe, in a particular position relative to the portion of the housing which is gripped by the operator and which position has been found to provide improved ergonomic use of the probe. Specifically, in the invention, the housing 10 is designed to  
15 provide an exit for a cable at a position below the portion of the housing which is gripped by the operator and structure for guiding the cable from the exit in a direction at a narrow angle to a horizontal plane of the housing. This is in contrast to prior art probes wherein the cable exits from a position above the portion of the housing of the probe which is gripped by the operator during use and in a direction perpendicular to the horizontal plane  
20 of the probe and perpendicular to the plane in which the operator's wrist is positioned during use of the probe.

To achieve this objective, reference is made to FIG. 2 which shows an ultrasonic transducer probe 20 including the housing 10 in accordance with the invention. As shown, the lower portion 14 of the housing 10 includes a cable exit opening 22 through which a  
25 cable 24 passes to connect the transducer 26 mounted in the housing 10 to the control unit (not shown). Wires 28 of the cable 24 are connected to the transducer 26 which may be any type of transducer capable of performing imaging. Thus, in the housing 10, the cable exit opening 22 is arranged below the upper portion 12 which is gripped by the operator during use of a probe including the housing 10.

30           The probe 20 also includes a convex lens 30 through which the ultrasonic waves pass to and from the active surface of the transducer 26. Lens 30 may be part of the housing 10 and attached thereto by any means known in the art, such as by an adhesive

agent. In the alternative, the lens 30 may be attached to or formed in connection with the transducer 26.

Moreover, to further improve the ergonomics of the housing 10, the housing 10 includes a cable conduit 32 leading from the cable exit opening 22 and which is designed to lead or orient the cable 24 out of the housing 10 in a particular direction. Specifically, the cable conduit 32 leads from the cable exit opening 22 in a direction at an angle to a horizontal plane 34 of the housing 10, horizontal plane 34 being a plane perpendicular to the vertical, central axis Y of the housing 10 (see FIG. 2). This angle is designated  $\alpha$  in FIG. 2 and ranges from about  $0^\circ$  to about  $30^\circ$ , an angle of  $0^\circ$  means that the cable conduit 32 leads the cable 24 out of the housing 10 in a direction parallel to the horizontal plane 34 of the housing 10. The transducer 26 is often usually arranged such that its active surface 26a is parallel to the horizontal plane 34 of the housing 10 and thus the cable 24 would exit in a direction at an angle to the active surface 26a of the transducer 26.

The specific angle at which the cable conduit 32 leads the cable 24 from the housing 10 depends in part on the distance between the outer edge 32a of the cable conduit 32 and the body-contacting plane 36 of the probe 20. Generally, if the outer edge 32a of the cable conduit 32 is close to a horizontal body-contacting plane 36 of the probe 20, then the angle  $\alpha$  will be higher than if the outer edge 32a is farther from the body-contacting plane 36. This is because a larger angle is needed the lower the outer edge 32a is to the body-contacting plane 36 in order to prevent the cable 22 from draping down onto the patient during examination.

In the probe 20, it is possible to selectively weight the probe 20 to balance it in its neutral position. This can be accomplished by filling a part or all of the available interior of the housing 10 with a loaded, flexible epoxy 58, or similar material, which may be appropriately loaded or weighted depending on the construction of the housing 10 and the cable 24 (see FIG. 2). For example, the loading of the epoxy 58 may be heavier in the front/nose 60 of the housing 10 of the probe 20 (that portion of the housing 10 opposite from the cable exit opening 22) to counterbalance the cable 24 (the heavier loading being represented by the gradually increasing dots toward the front/nose 60 in FIG. 2). This intentional weighting of the interior of the probe 20 is effective to counterbalance residual torque caused by the cable 24, which may occur in spite of the specific positioning of the cable exit 32 as described above.

An EMI-RFI shield layer 62 may also be provided around the transducer 26.

Referring now to FIGS. 3-10, housing 10 may be made of two components 38,40, which are substantially mirror-image components (with some differences as described below). Each housing component 38,40 may be made of molded plastic or similar material(s). Although the illustrated embodiment shows the fabrication of the housing 10 from two separate components which are attached together to form the complete housing 10, it is possible and conceivable to form the housing 10 from a unitary member and this form of construction is also intended to be within the scope of the invention.

The first housing component 38 is shown in FIGS. 3-6 and has a hemispherical portion 42a which provides half of the upper portion 12 of the housing 10 and a lower arcuate portion 44a which provides half of the lower portion 14 and includes a channel 46a which provides half of the cable conduit 32. A recess 48a is defined by the inwardly directed flanges 50a which corresponds to half of the opening 18 defined by the lips 16. One or more mounting mechanisms 52a are formed on the inner surface of the component 38 to enable the transducer 26 and/or other internal probe electronics to be mounted thereto. To enable connection of the housing components 38, 40 together, the housing component 38 includes a projection 54 extending from a lateral surface defining an edge of the housing component 38, and the projection 54 is designed to mate with a corresponding recess 56 formed in a lateral surface defining an edge of the housing component 40.

The second housing component 40 is shown in FIGS. 7-10 and has a hemispherical portion 42b which provides half of the upper portion 12 of the housing 10 and a lower arcuate portion 44b which provides half of the lower portion 14 and includes a channel 46b which provides half of the cable conduit 32. A recess 48b is defined by the inwardly directed flanges 50b which corresponds to half of the opening 18 defined by the lips 16. Instead of or in addition to the mounting mechanisms 52a formed on the inner surface of the first housing component 38, one or more mounting mechanisms 52b may be formed on the inner surface of the second housing component 40 to enable the transducer 26 and/or other internal probe electronics to be mounted thereto. As noted above, a recess 56 is formed in a lateral surface defining an edge of the housing component and accommodates the projection 54 extending from the lateral surface defining the edge of the first housing component. Other mechanisms for attaching the first and second housing components 38,40 together can also be used in the invention.



- To assemble the probe 20, the electronics to be placed in the interior of the housing 10, e.g., the transducer 26, are connected to wires 28 of a cable 24, and mounted to one of the housing components, e.g., the first housing component 38, via the respective mounting mechanism 52a and such that the cable 24 passes through the channel 46a. The second
- 5 housing component 40 is then attached to the first housing component 38 having the transducer 26 mounted thereto via the cooperating projection 54 and recess 56 in the lateral edges of the housing components 38,40. At the same time, the mounting mechanism 52b in the second housing component 40 may be coupled to the electronics to thereby secure the transducer 26 within the housing 10. If the lens 30 is part of the housing 10, then it is first
- 10 attached to one of the housing 38, 40 and then to the other housing component 38, 40 when the housing components 38, 40 are attached to one another. If the lens 30 is part of the transducer 26, then it is mounted to the first housing component 38 and adhered thereto and then when the second housing component 40 is attached to the first housing component 38, it is attached thereto.
- 15 In view of the positioning of the cable exit opening 22 below the upper portion 12 of the housing 10 which is gripped by the operator and orienting it at a non-perpendicular angle to the horizontal plane 34 of the housing 10, the effective contribution of weight/torque by the cable 24 during use of the probe 20 is minimized. An effectively ergonomic housing for a transducer probe is therefore provided.
- 20 Although illustrative embodiments of the present invention have been described herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to these precise embodiments, and that various other changes and modifications may be effected therein by one of ordinary skill in the art without departing from the scope or spirit of the invention.

## CLAIMS:

1. A housing for a transducer probe, comprising:
  - an upper portion defining a substantially spherical outer surface adapted to be gripped by an operator of the probe; and
  - a lower portion defining a bottom of the housing and a cable exit opening adapted to enable a cable to pass from an interior of said housing to an exterior of said housing, said cable exit opening being positioned between the bottom of said housing and said upper portion.
2. The housing of claim 1, wherein said lower portion includes a cable conduit extending from said cable exit opening and adapted to lead the cable out of said interior of said housing at an angle of about 0° to about 30° relative to a horizontal plane of said housing perpendicular to a central, vertical axis of said housing.
3. The housing of claim 2, wherein said housing comprises first and second housing components, each of said first and second housing components providing approximately half of said upper portion and half of said lower portion.
4. The housing of claim 3, wherein each of said first and second housing components has a hemispherical portion which provides half of said upper portion of said housing and a lower arcuate portion which provides half of said lower portion and includes a channel which provides half of said cable conduit.
5. The housing of claim 3, wherein at least one of said first and second housing components includes a mounting mechanism for enabling mounting of a transducer in said housing.
6. The housing of claim 3, wherein said first and second housing components comprise attachment means for enabling attachment of said first and second housing components together.
7. The housing of claim 6, wherein said attachment means comprise a projection arranged on said first housing component and a corresponding recess formed on said second housing component.
8. The housing of claim 1, wherein said upper portion is substantially spherical.
9. The housing of claim 1, wherein said lower portion has the approximate shape of truncated cone.

10. The housing of claim 1, wherein said lower portion defines an opening through which waves are transmitted and received during use of the probe.
11. The housing of claim 1, further comprising a lens arranged at the bottom of said housing.
12. A transducer probe, comprising:
  - a housing defining an interior;
  - a transducer arranged in said interior of said housing and having an active surface oriented toward a bottom of said housing; and
  - a cable for connecting said transducer to a control unit of the probe,said housing including an upper portion defining a substantially spherical outer surface adapted to be gripped by an operator of the probe and a lower portion defining a bottom of the housing and a cable exit opening through which said cable passes from an interior of said housing to an exterior of said housing, said cable exit opening being positioned between the bottom of said housing and said upper portion.
13. The probe of claim 12, wherein said lower portion includes a cable conduit extending from said cable exit opening and leading said cable out of said interior of said housing at an angle of about 0° to about 30° relative to a horizontal plane of said housing perpendicular to a central, vertical axis of said housing.
14. The probe of claim 13, wherein said housing comprises first and second housing components, each of said first and second housing components providing approximately half of said upper portion and half of said lower portion.
15. The probe of claim 14, wherein each of said first and second housing components has a hemispherical portion which provides half of said upper portion of said housing and a lower arcuate portion which provides half of said lower portion and includes a channel which provides half of said cable conduit.
16. The probe of claim 14, wherein at least one of said first and second housing components includes a mounting mechanism for enabling mounting of said transducer in said housing.
17. The probe of claim 14, wherein said first and second housing components comprise attachment means for enabling attachment of said first and second housing components together.
18. The probe of claim 12, wherein said upper portion is substantially spherical.

19. The probe of claim 12, further comprising a loadable, flexible epoxy material arranged in an interior of said housing, said epoxy material being variably loaded to counter balance said cable.

20. The probe of claim 12, wherein said transducer is an ultrasonic transducer and said lower portion defines a opening through which ultrasonic waves are transmitted and received by said ultrasonic transducer during use of the probe.

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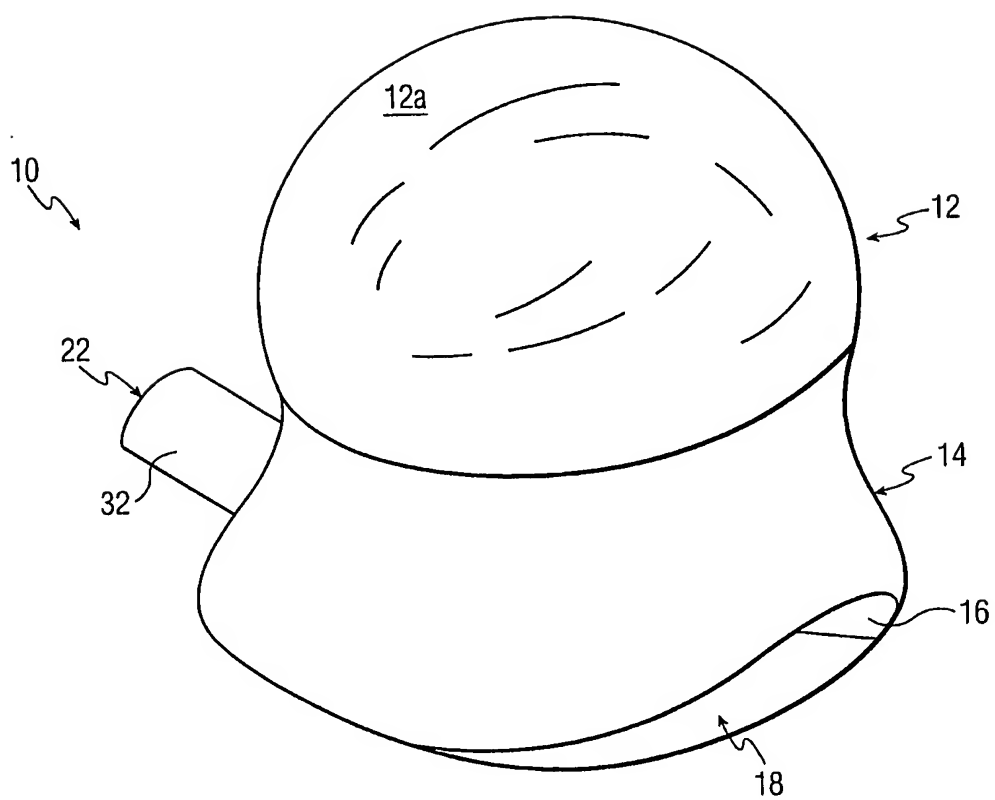


FIG. 1

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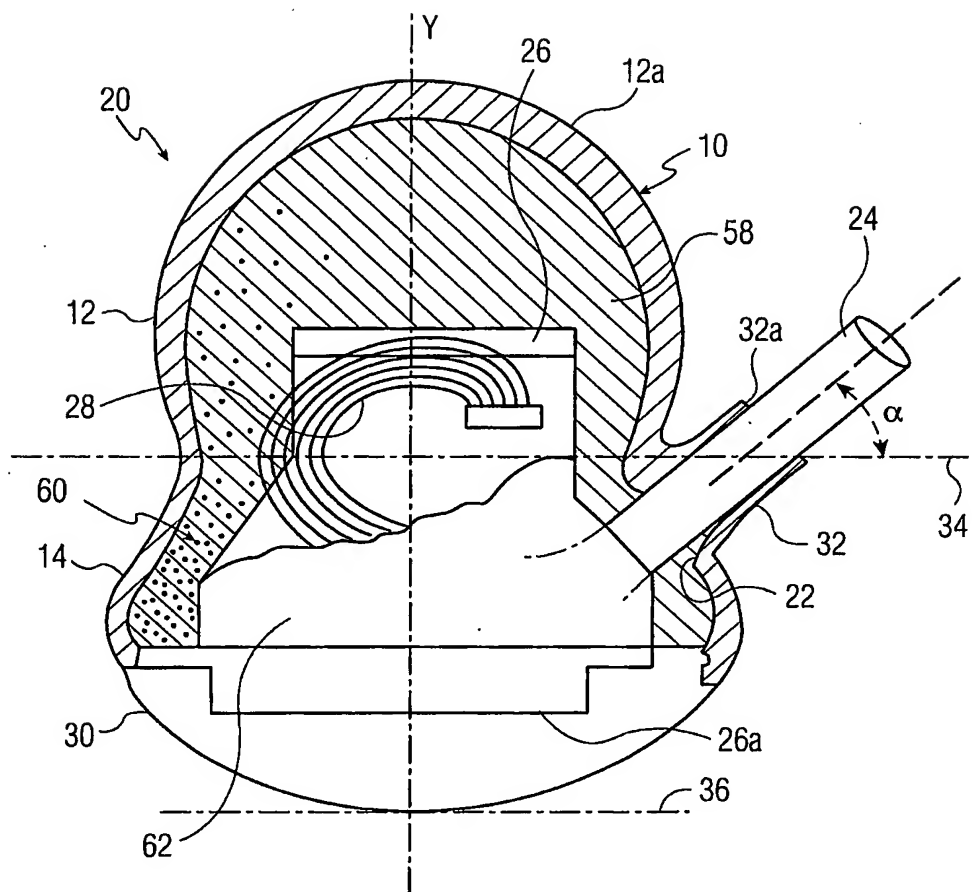


FIG. 2

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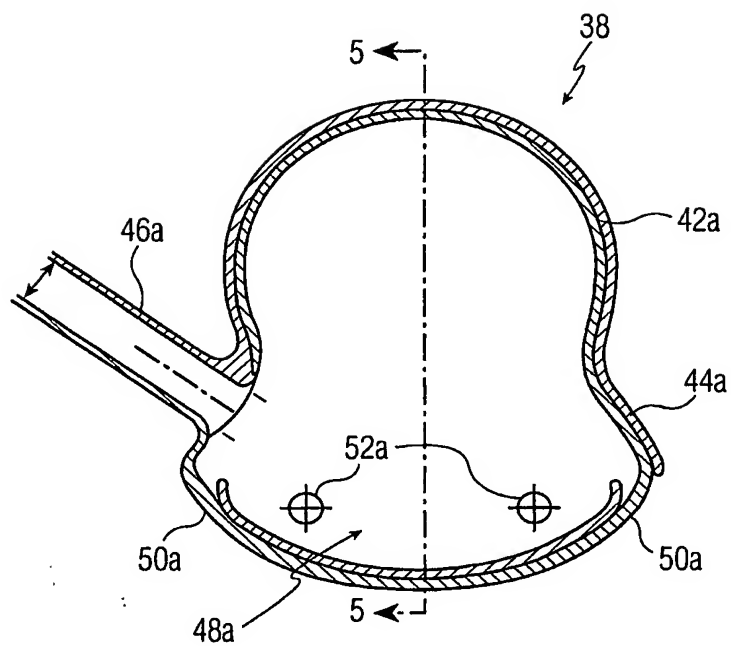


FIG. 3

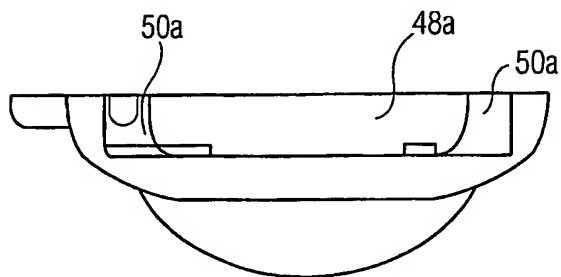


FIG. 4

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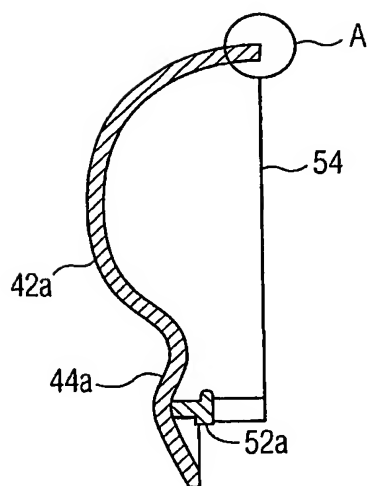


FIG. 5

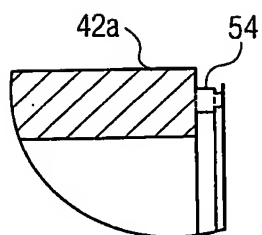


FIG. 6



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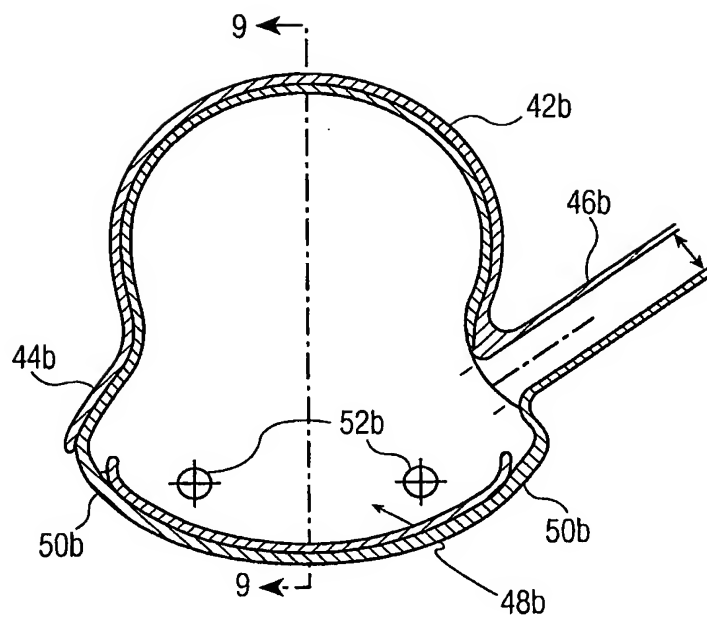


FIG. 7

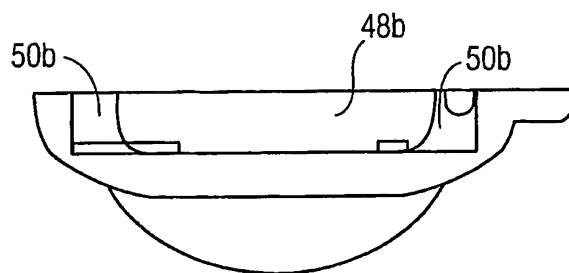


FIG. 8

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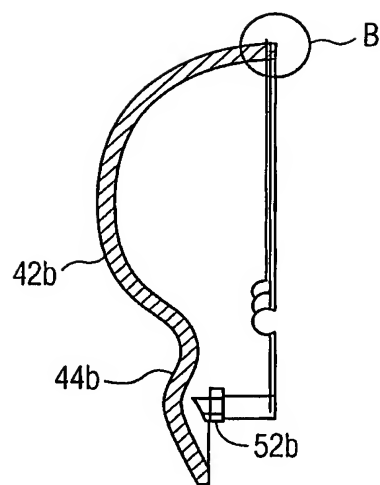


FIG. 9

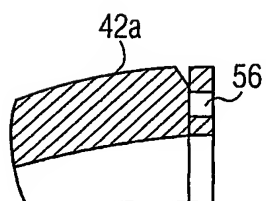


FIG. 10

# INTERNATIONAL SEARCH REPORT

International Application No

PC B2004/052623

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 A61B8/00 G01N29/24

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61B G01N G09B F21V G05G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 752 517 A (HARMAN ET AL) 19 May 1998 (1998-05-19)	1-3,5,6, 8-14, 16-18,20
Y	column 2, line 1 - line 50 figures 1,2	4,15
Y	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 06, 30 June 1997 (1997-06-30) & JP 09 033496 A (NOHMI BOSAI LTD), 7 February 1997 (1997-02-07) abstract	4,15
A	paragraphs [0015], [0016]; figures 1,2	1,5, 8-10,12, 16,18

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

5 April 2005

Date of mailing of the international search report

17 JUN 2005

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Authorized officer

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/IB2004/052623

## Box II Observations where certain claims were found unsearchable (Continuation of Item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box III Observations where unity of invention is lacking (Continuation of Item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-6, 8-18, 20

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.  
☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6, 8-18, 20

Hemispherical portions  
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2. claim: 7

Projection and recess  
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3. claim: 19

Counterbalancing epoxy  
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/JP2004/052623

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5752517	A	19-05-1998	NONE	
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JP 09033496	A	07-02-1997	NONE	
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